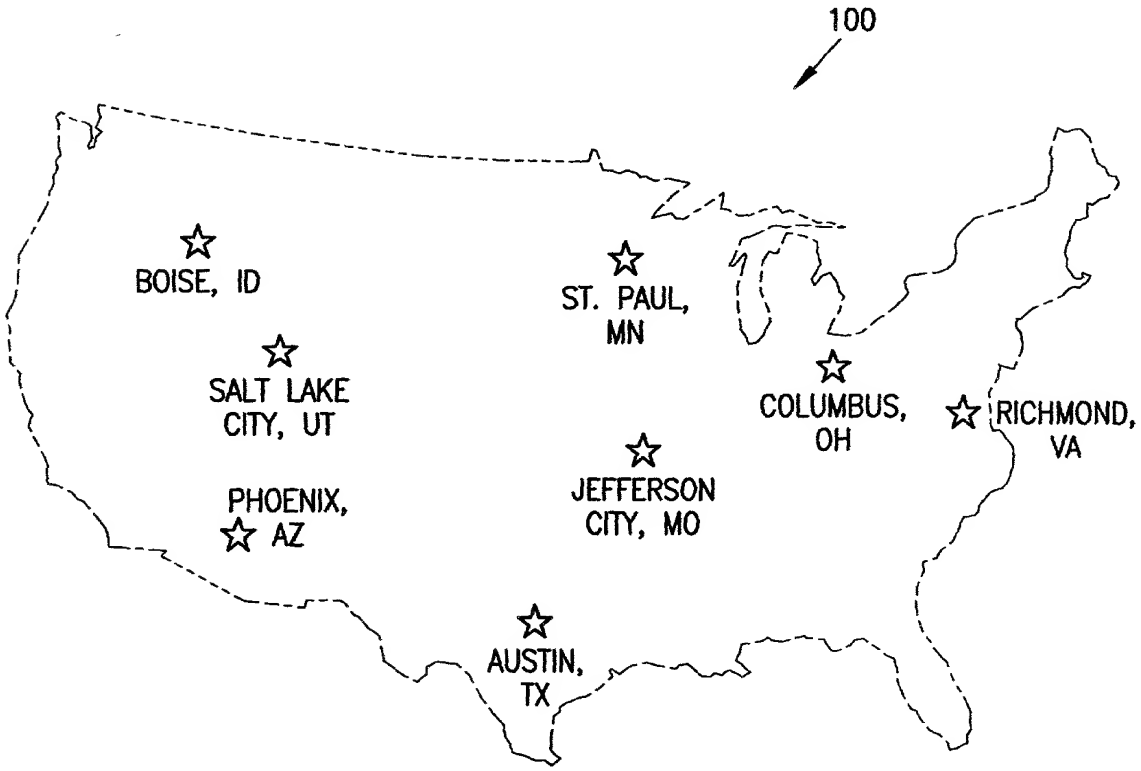
100
BOISE, ID
ST. PAUL, MN
SALT LAKE CITY, UT
COLUMBUS, OH
RICHMOND, VA
JEFFERSON CITY, MO
PHOENIX, AZ
AUSTIN, TX

FIG. 1

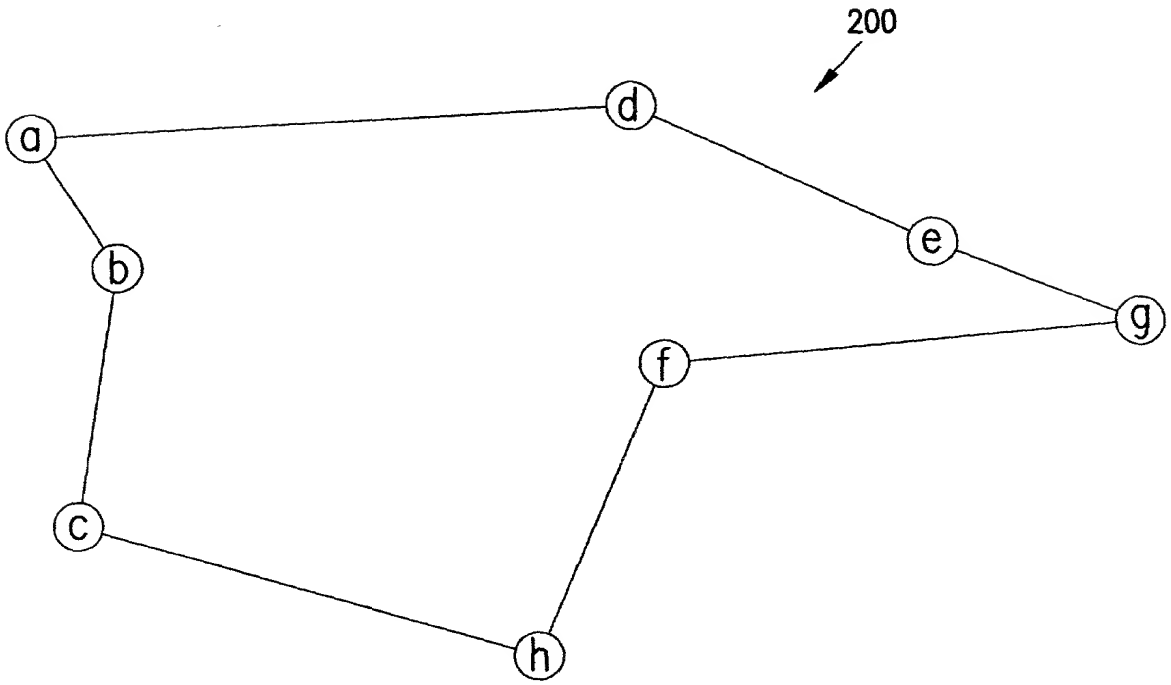

FIG. 2

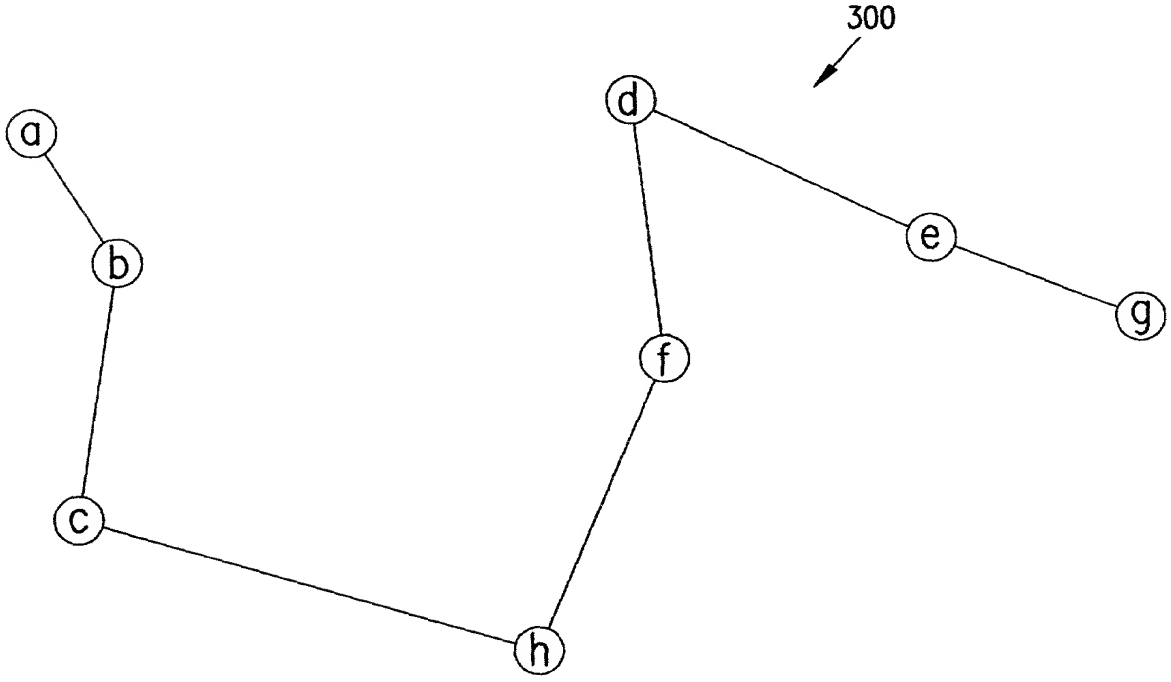

FIG. 3

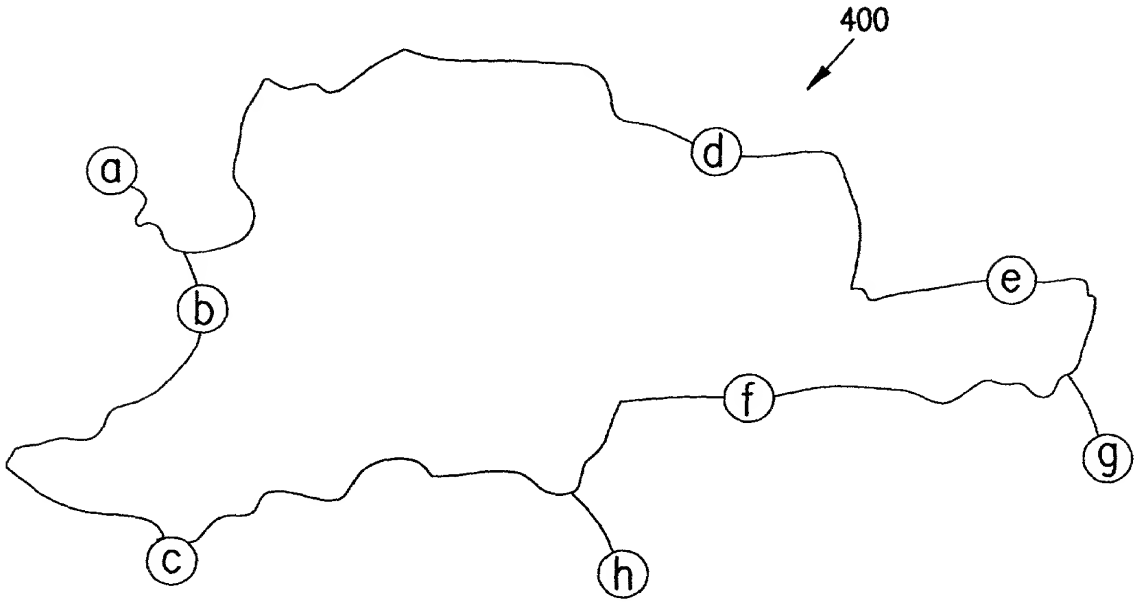

FIG. 4

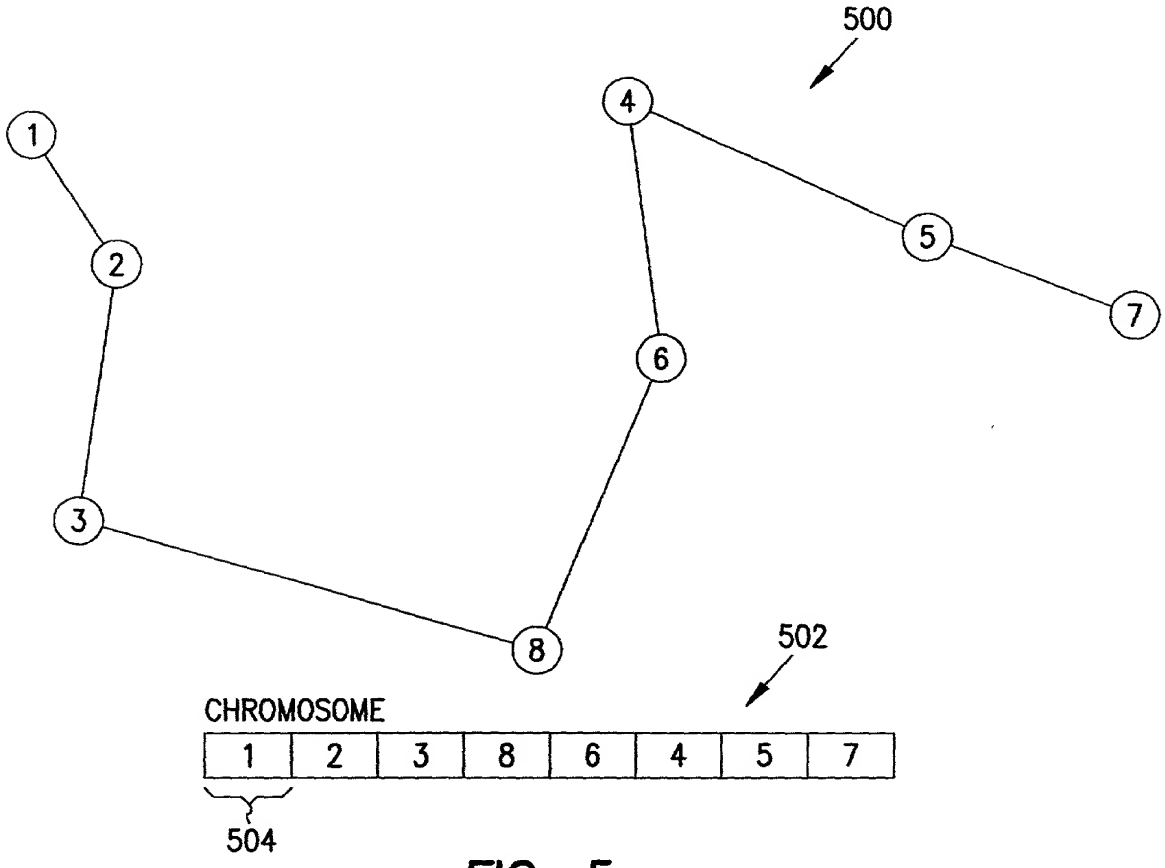

FIG. 5

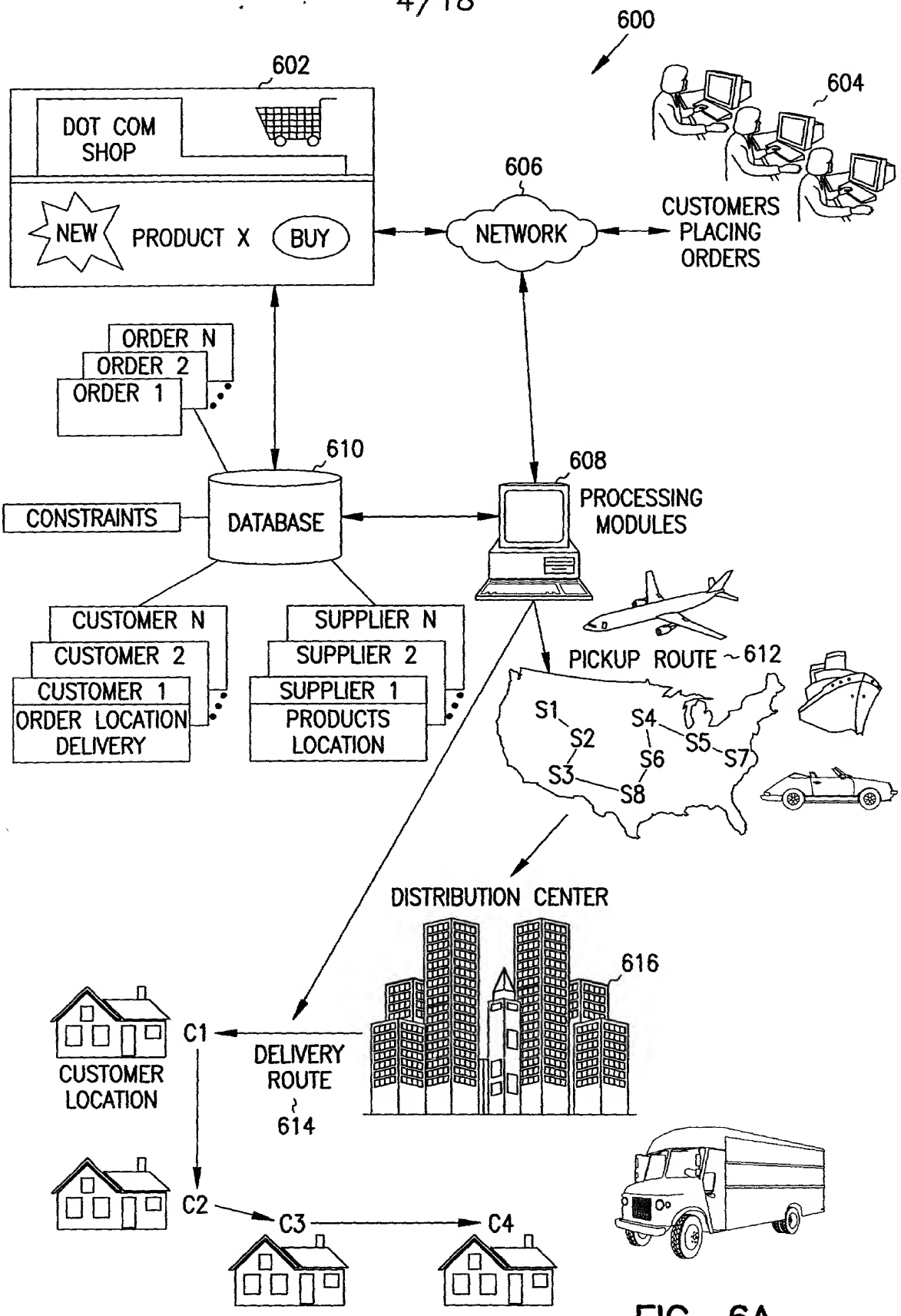
600
602
DOT COM SHOP
NEW
PRODUCT X
BUY
604
606
NETWORK
CUSTOMERS PLACING ORDERS
ORDER N
ORDER 2
ORDER 1
610
608
CONSTRAINTS
DATABASE
PROCESSING MODULES
CUSTOMER N
CUSTOMER 2
CUSTOMER 1
ORDER LOCATION DELIVERY
SUPPLIER N
SUPPLIER 2
SUPPLIER 1
PRODUCTS LOCATION
PICKUP ROUTE
612
S1
S2
S3
S4
S5
S6
S7
S8
DISTRIBUTION CENTER
616
C1
CUSTOMER LOCATION
DELIVERY ROUTE
614
C2
C3
C4

FIG. 6A

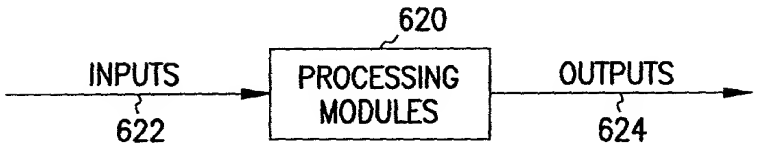
620
INPUTS
622
PROCESSING MODULES
OUTPUTS
624

FIG. 6B

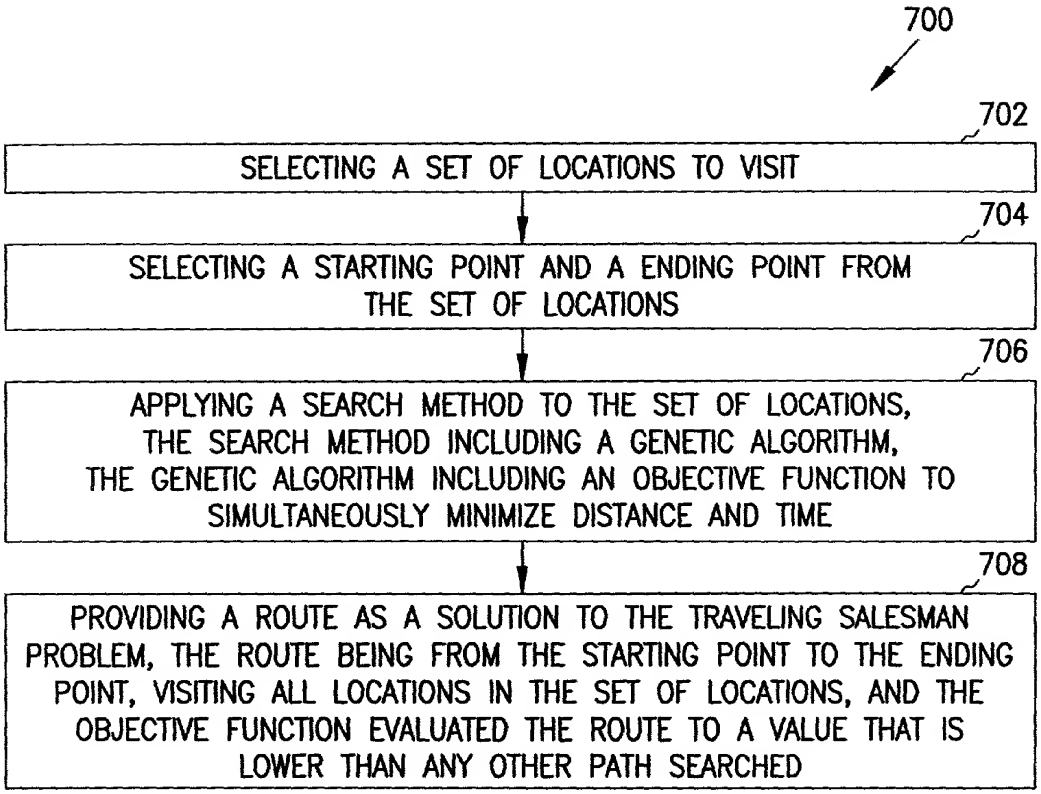
700
702
SELECTING A SET OF LOCATIONS TO VISIT
704
SELECTING A STARTING POINT AND A ENDING POINT FROM THE SET OF LOCATIONS
706
APPLYING A SEARCH METHOD TO THE SET OF LOCATIONS, THE SEARCH METHOD INCLUDING A GENETIC ALGORITHM, THE GENETIC ALGORITHM INCLUDING AN OBJECTIVE FUNCTION TO SIMULTANEOUSLY MINIMIZE DISTANCE AND TIME
708
PROVIDING A ROUTE AS A SOLUTION TO THE TRAVELING SALESMAN PROBLEM, THE ROUTE BEING FROM THE STARTING POINT TO THE ENDING POINT, VISITING ALL LOCATIONS IN THE SET OF LOCATIONS, AND THE OBJECTIVE FUNCTION EVALUATED THE ROUTE TO A VALUE THAT IS LOWER THAN ANY OTHER PATH SEARCHED

FIG. 7

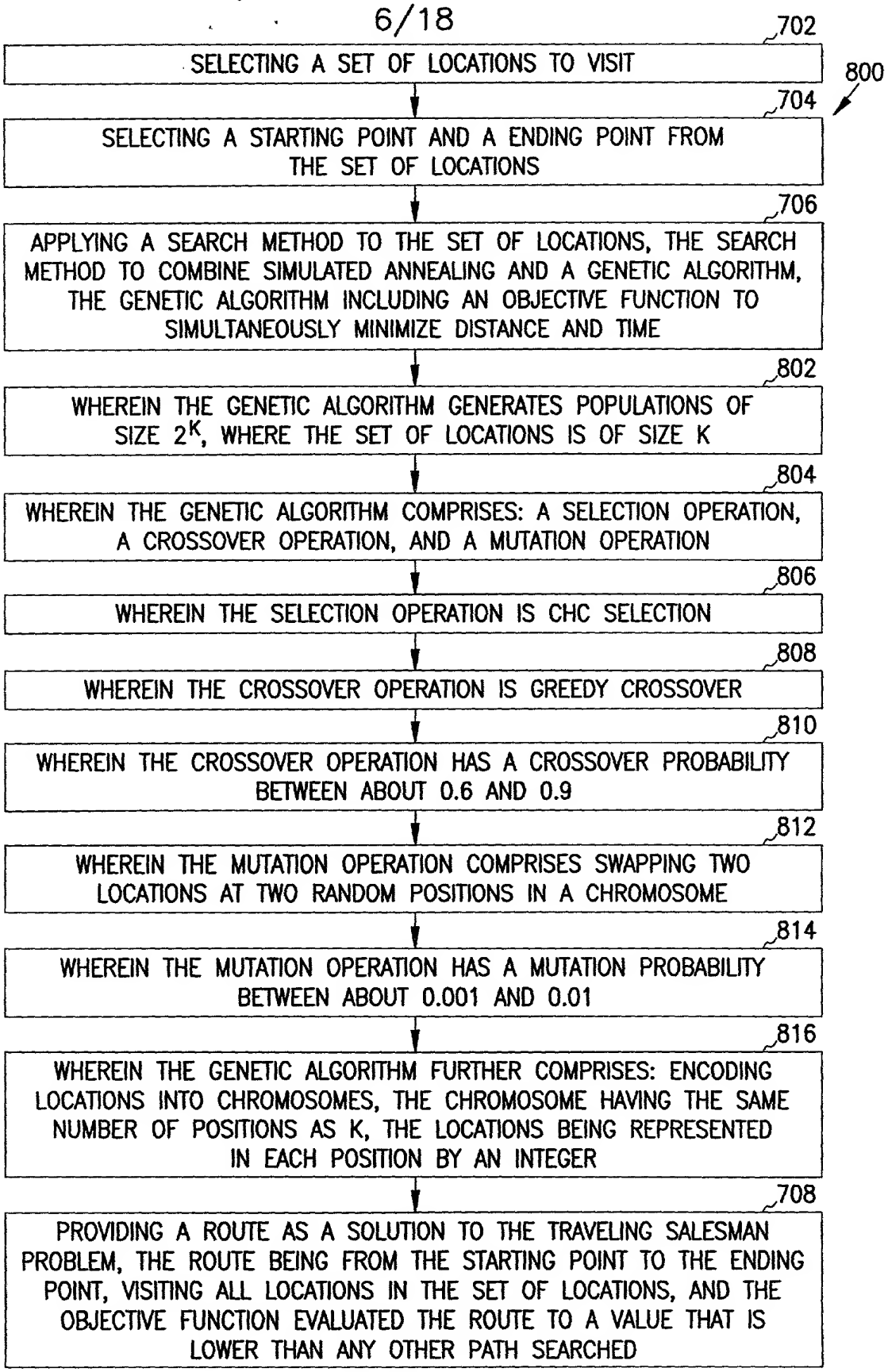

FIG. 8

Express Mail Label No. EV 324 538 125 US

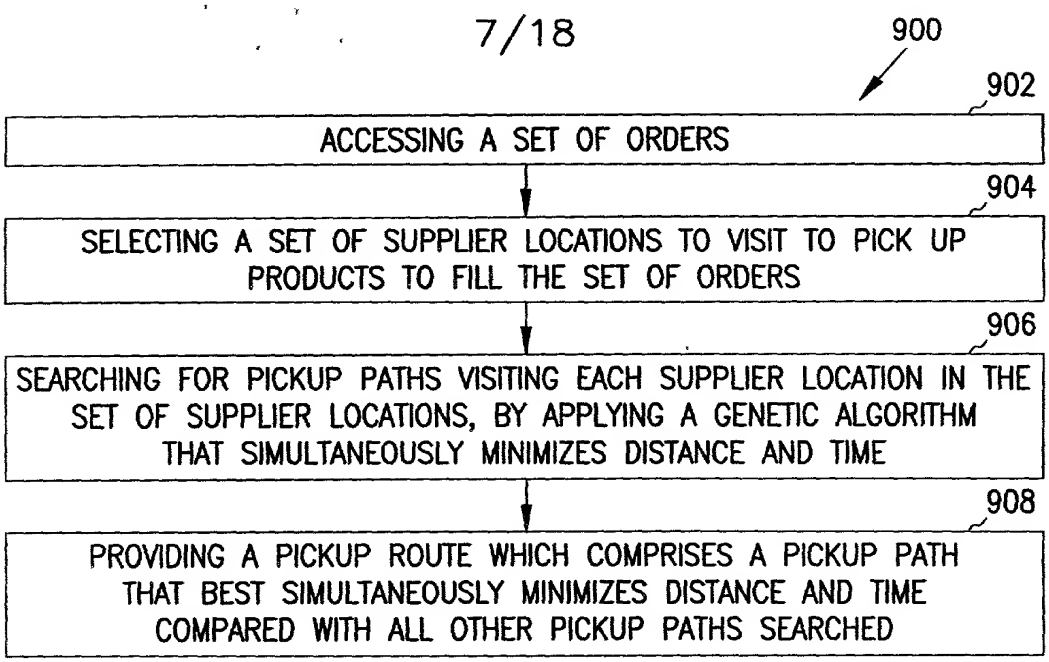
900
902
ACCESSING A SET OF ORDERS
904
SELECTING A SET OF SUPPLIER LOCATIONS TO VISIT TO PICK UP PRODUCTS TO FILL THE SET OF ORDERS
906
SEARCHING FOR PICKUP PATHS VISITING EACH SUPPLIER LOCATION IN THE SET OF SUPPLIER LOCATIONS, BY APPLYING A GENETIC ALGORITHM THAT SIMULTANEOUSLY MINIMIZES DISTANCE AND TIME
908
PROVIDING A PICKUP ROUTE WHICH COMPRISES A PICKUP PATH THAT BEST SIMULTANEOUSLY MINIMIZES DISTANCE AND TIME COMPARED WITH ALL OTHER PICKUP PATHS SEARCHED

FIG. 9

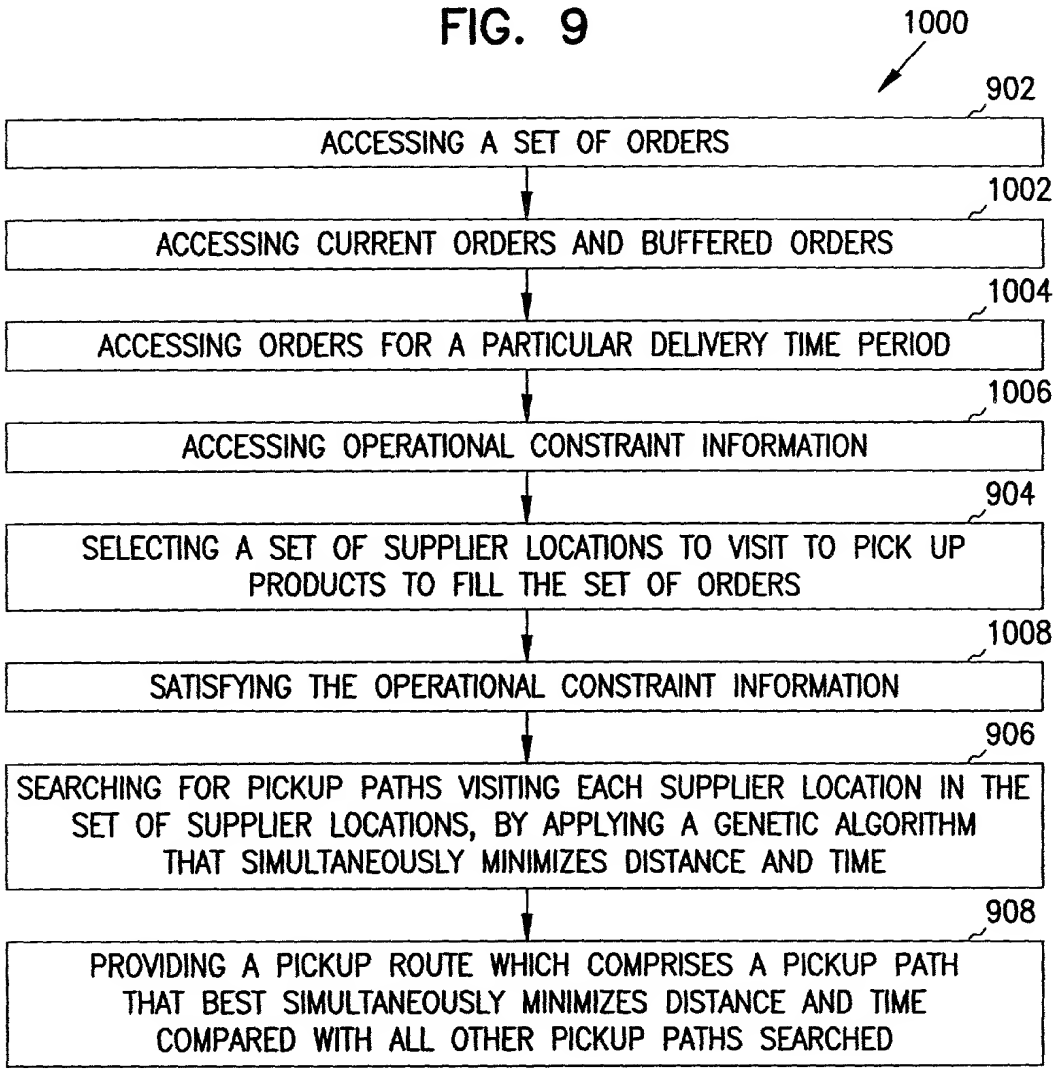
1000
902
ACCESSING A SET OF ORDERS
1002
ACCESSING CURRENT ORDERS AND BUFFERED ORDERS
1004
ACCESSING ORDERS FOR A PARTICULAR DELIVERY TIME PERIOD
1006
ACCESSING OPERATIONAL CONSTRAINT INFORMATION
904
SELECTING A SET OF SUPPLIER LOCATIONS TO VISIT TO PICK UP PRODUCTS TO FILL THE SET OF ORDERS
1008
SATISFYING THE OPERATIONAL CONSTRAINT INFORMATION
906
SEARCHING FOR PICKUP PATHS VISITING EACH SUPPLIER LOCATION IN THE SET OF SUPPLIER LOCATIONS, BY APPLYING A GENETIC ALGORITHM THAT SIMULTANEOUSLY MINIMIZES DISTANCE AND TIME
908
PROVIDING A PICKUP ROUTE WHICH COMPRISES A PICKUP PATH THAT BEST SIMULTANEOUSLY MINIMIZES DISTANCE AND TIME COMPARED WITH ALL OTHER PICKUP PATHS SEARCHED

FIG. 10

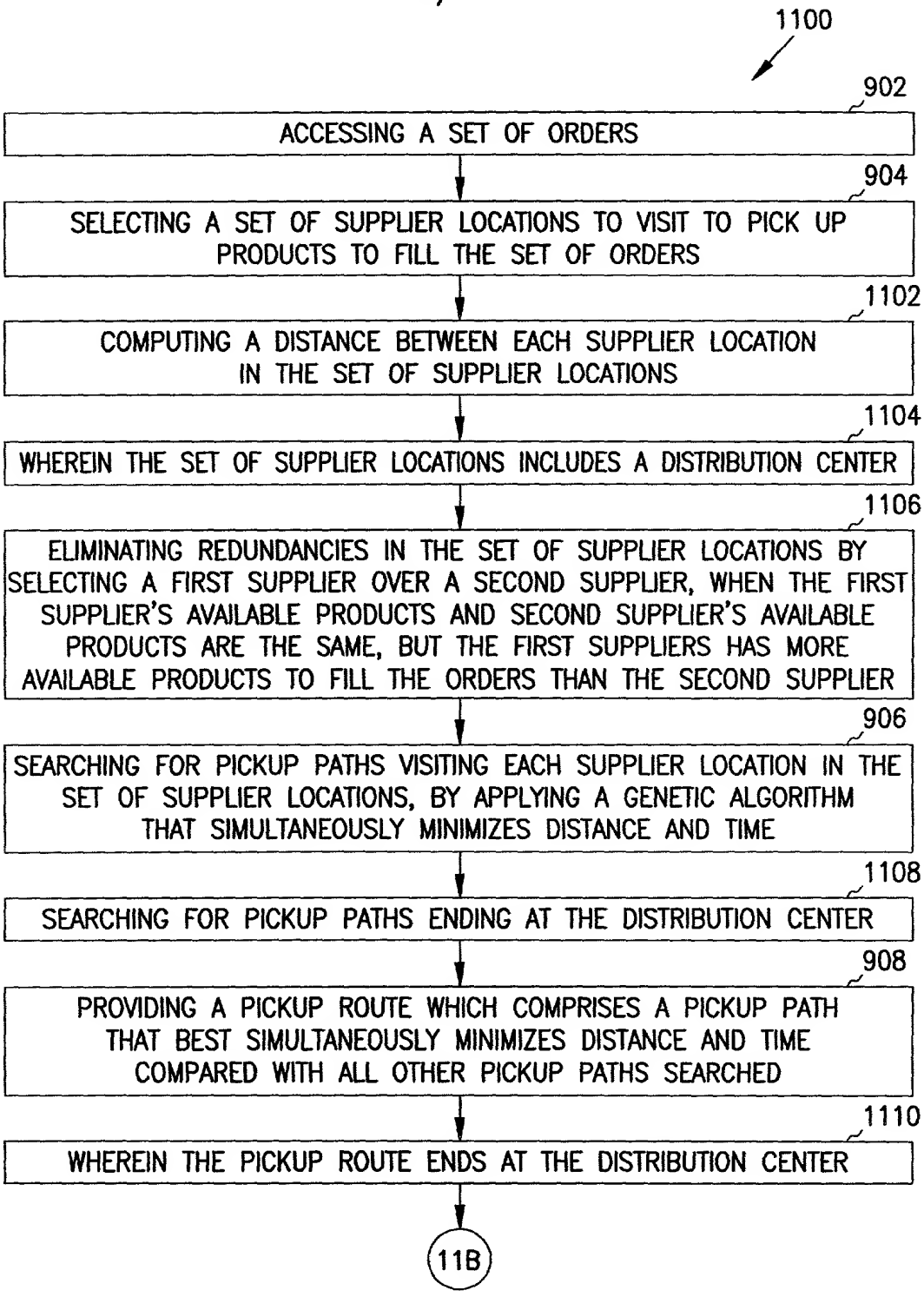
1100
902
ACCESSING A SET OF ORDERS
904
SELECTING A SET OF SUPPLIER LOCATIONS TO VISIT TO PICK UP PRODUCTS TO FILL THE SET OF ORDERS
1102
COMPUTING A DISTANCE BETWEEN EACH SUPPLIER LOCATION IN THE SET OF SUPPLIER LOCATIONS
1104
WHEREIN THE SET OF SUPPLIER LOCATIONS INCLUDES A DISTRIBUTION CENTER
1106
ELIMINATING REDUNDANCIES IN THE SET OF SUPPLIER LOCATIONS BY SELECTING A FIRST SUPPLIER OVER A SECOND SUPPLIER, WHEN THE FIRST SUPPLIER'S AVAILABLE PRODUCTS AND SECOND SUPPLIER'S AVAILABLE PRODUCTS ARE THE SAME, BUT THE FIRST SUPPLIERS HAS MORE AVAILABLE PRODUCTS TO FILL THE ORDERS THAN THE SECOND SUPPLIER
906
SEARCHING FOR PICKUP PATHS VISITING EACH SUPPLIER LOCATION IN THE SET OF SUPPLIER LOCATIONS, BY APPLYING A GENETIC ALGORITHM THAT SIMULTANEOUSLY MINIMIZES DISTANCE AND TIME
1108
SEARCHING FOR PICKUP PATHS ENDING AT THE DISTRIBUTION CENTER
908
PROVIDING A PICKUP ROUTE WHICH COMPRISES A PICKUP PATH THAT BEST SIMULTANEOUSLY MINIMIZES DISTANCE AND TIME COMPARED WITH ALL OTHER PICKUP PATHS SEARCHED
1110
WHEREIN THE PICKUP ROUTE ENDS AT THE DISTRIBUTION CENTER
11B

FIG. 11A

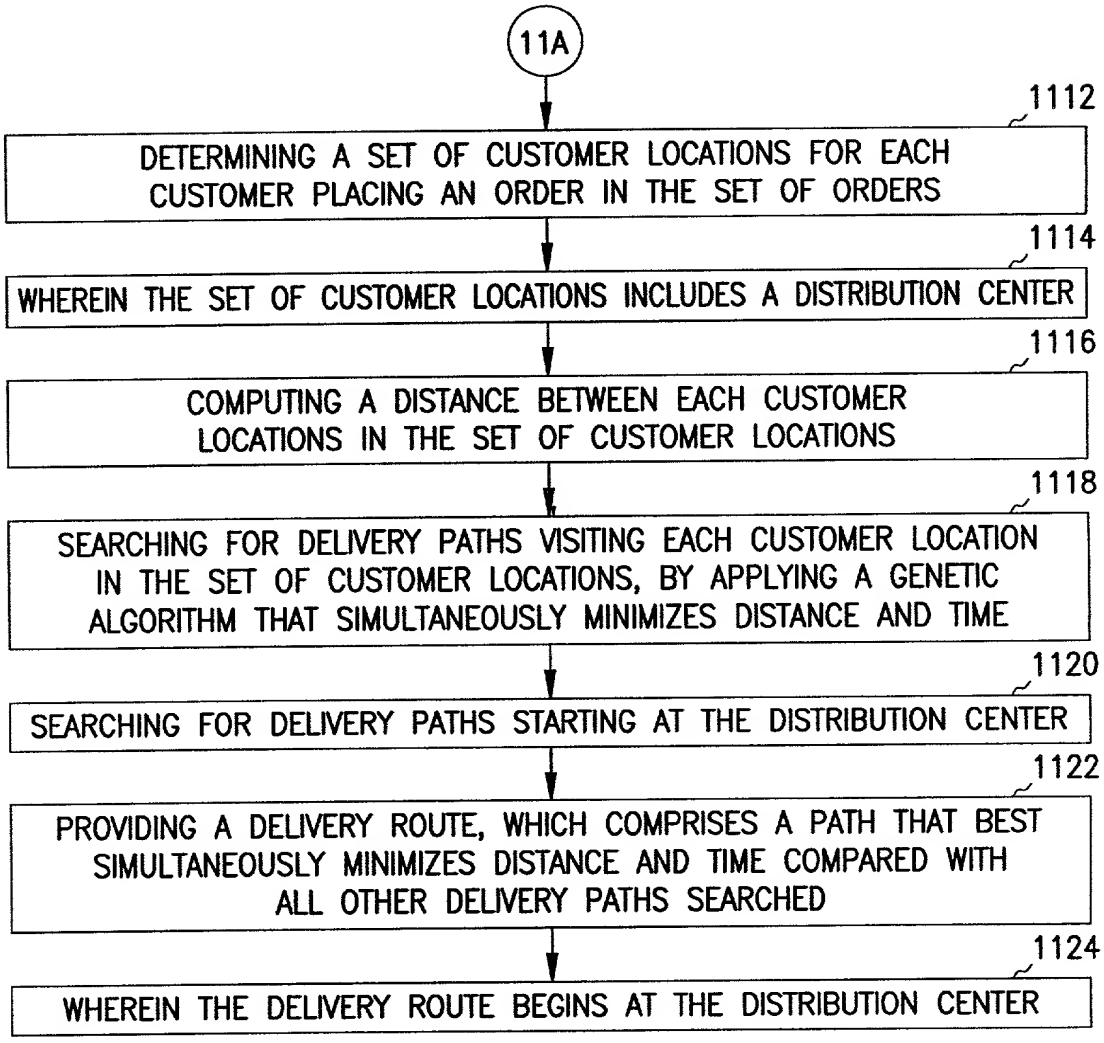
11A
1112
DETERMINING A SET OF CUSTOMER LOCATIONS FOR EACH CUSTOMER PLACING AN ORDER IN THE SET OF ORDERS
1114
WHEREIN THE SET OF CUSTOMER LOCATIONS INCLUDES A DISTRIBUTION CENTER
1116
COMPUTING A DISTANCE BETWEEN EACH CUSTOMER LOCATIONS IN THE SET OF CUSTOMER LOCATIONS
1118
SEARCHING FOR DELIVERY PATHS VISITING EACH CUSTOMER LOCATION IN THE SET OF CUSTOMER LOCATIONS, BY APPLYING A GENETIC ALGORITHM THAT SIMULTANEOUSLY MINIMIZES DISTANCE AND TIME
1120
SEARCHING FOR DELIVERY PATHS STARTING AT THE DISTRIBUTION CENTER
1122
PROVIDING A DELIVERY ROUTE, WHICH COMPRISES A PATH THAT BEST SIMULTANEOUSLY MINIMIZES DISTANCE AND TIME COMPARED WITH ALL OTHER DELIVERY PATHS SEARCHED
1124
WHEREIN THE DELIVERY ROUTE BEGINS AT THE DISTRIBUTION CENTER

FIG. 11B

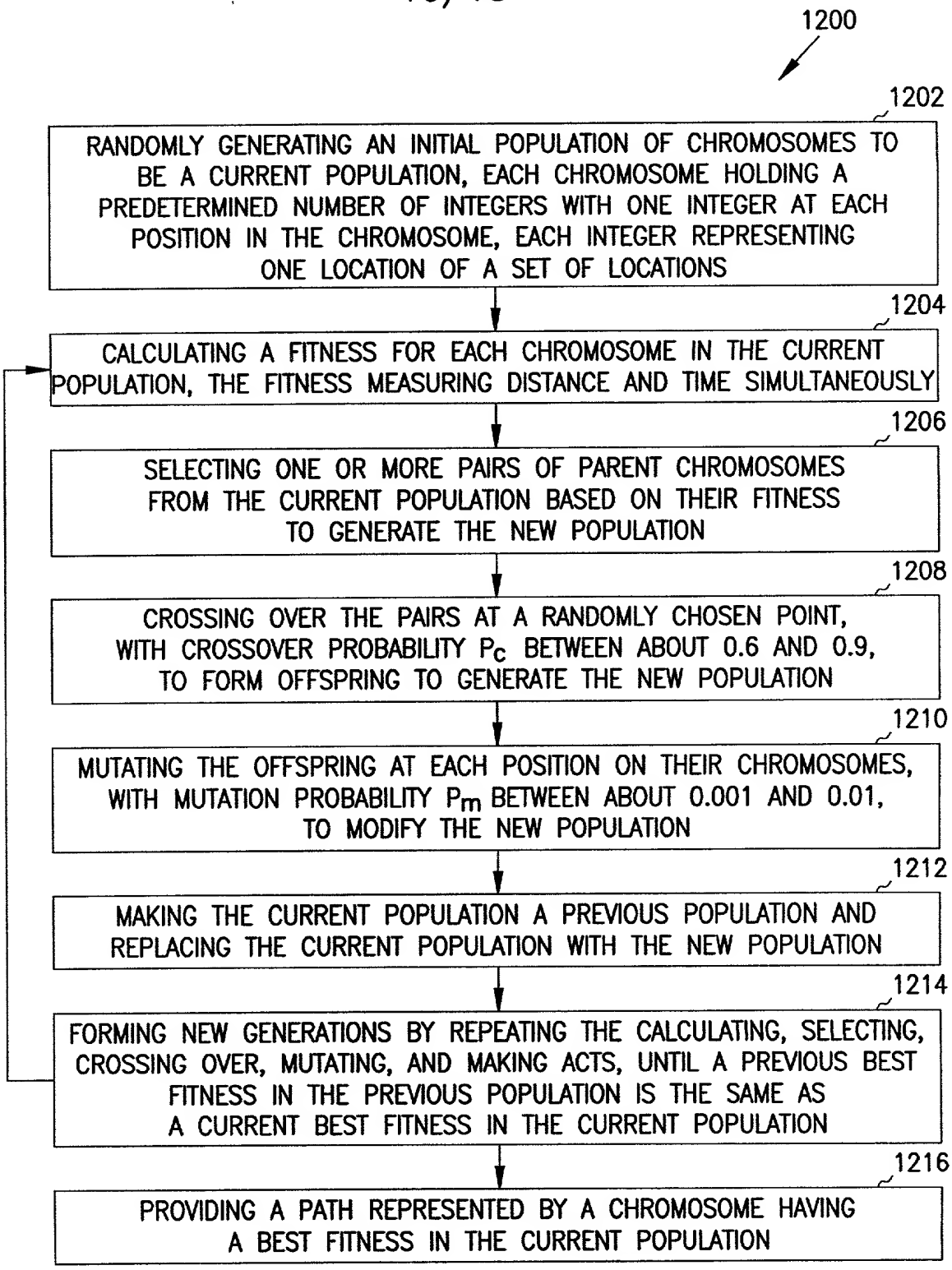
1200
1202
RANDOMLY GENERATING AN INITIAL POPULATION OF CHROMOSOMES TO BE A CURRENT POPULATION, EACH CHROMOSOME HOLDING A PREDETERMINED NUMBER OF INTEGERS WITH ONE INTEGER AT EACH POSITION IN THE CHROMOSOME, EACH INTEGER REPRESENTING ONE LOCATION OF A SET OF LOCATIONS
1204
CALCULATING A FITNESS FOR EACH CHROMOSOME IN THE CURRENT POPULATION, THE FITNESS MEASURING DISTANCE AND TIME SIMULTANEOUSLY
1206
SELECTING ONE OR MORE PAIRS OF PARENT CHROMOSOMES FROM THE CURRENT POPULATION BASED ON THEIR FITNESS TO GENERATE THE NEW POPULATION
1208
CROSSING OVER THE PAIRS AT A RANDOMLY CHOSEN POINT, WITH CROSSOVER PROBABILITY P_c BETWEEN ABOUT 0.6 AND 0.9, TO FORM OFFSPRING TO GENERATE THE NEW POPULATION
1210
MUTATING THE OFFSPRING AT EACH POSITION ON THEIR CHROMOSOMES, WITH MUTATION PROBABILITY P_m BETWEEN ABOUT 0.001 AND 0.01, TO MODIFY THE NEW POPULATION
1212
MAKING THE CURRENT POPULATION A PREVIOUS POPULATION AND REPLACING THE CURRENT POPULATION WITH THE NEW POPULATION
1214
FORMING NEW GENERATIONS BY REPEATING THE CALCULATING, SELECTING, CROSSING OVER, MUTATING, AND MAKING ACTS, UNTIL A PREVIOUS BEST FITNESS IN THE PREVIOUS POPULATION IS THE SAME AS A CURRENT BEST FITNESS IN THE CURRENT POPULATION
1216
PROVIDING A PATH REPRESENTED BY A CHROMOSOME HAVING A BEST FITNESS IN THE CURRENT POPULATION

FIG. 12

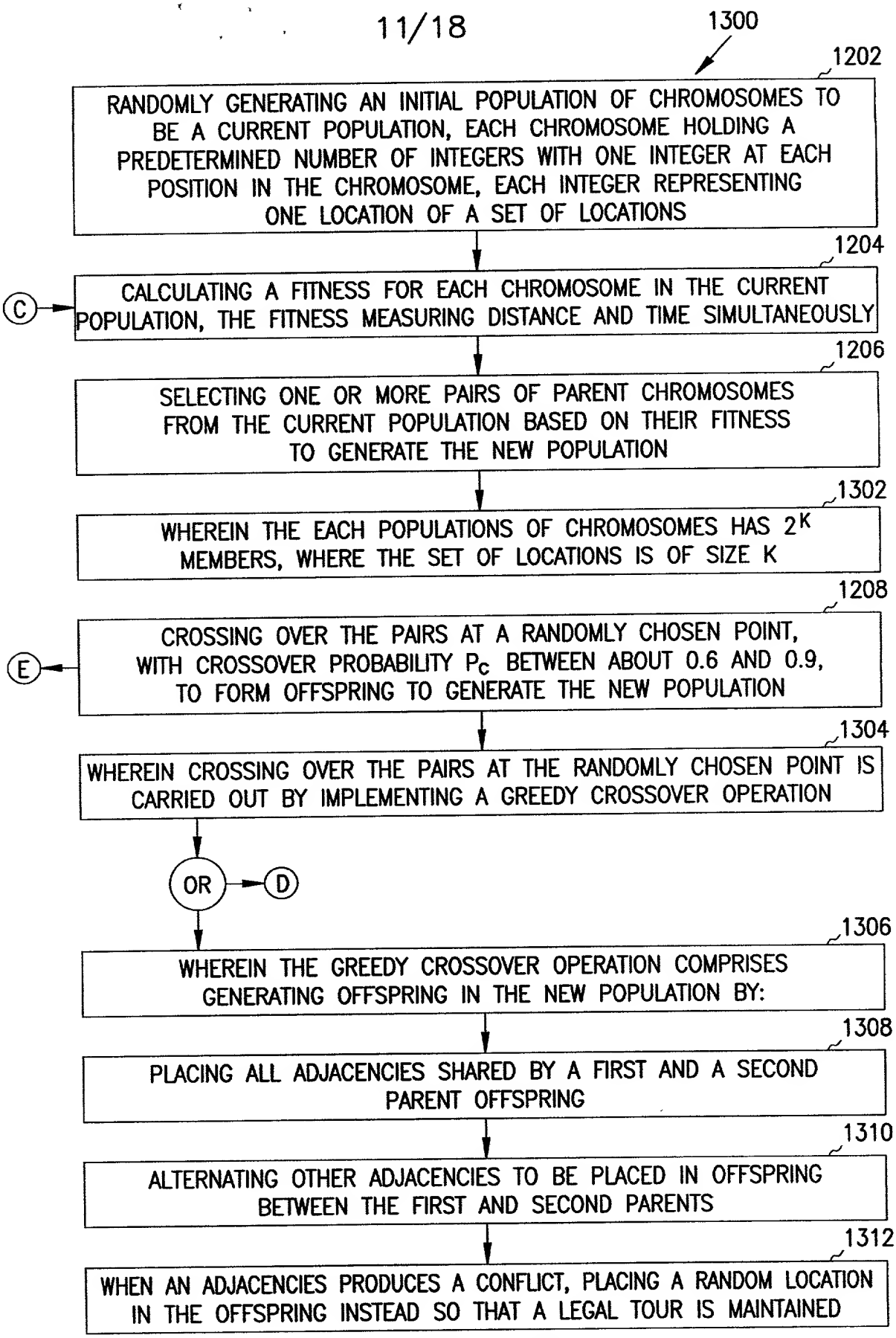
1300
1202
RANDOMLY GENERATING AN INITIAL POPULATION OF CHROMOSOMES TO BE A CURRENT POPULATION, EACH CHROMOSOME HOLDING A PREDETERMINED NUMBER OF INTEGERS WITH ONE INTEGER AT EACH POSITION IN THE CHROMOSOME, EACH INTEGER REPRESENTING ONE LOCATION OF A SET OF LOCATIONS
1204
C
CALCULATING A FITNESS FOR EACH CHROMOSOME IN THE CURRENT POPULATION, THE FITNESS MEASURING DISTANCE AND TIME SIMULTANEOUSLY
1206
SELECTING ONE OR MORE PAIRS OF PARENT CHROMOSOMES FROM THE CURRENT POPULATION BASED ON THEIR FITNESS TO GENERATE THE NEW POPULATION
1302
WHEREIN THE EACH POPULATIONS OF CHROMOSOMES HAS 2^K MEMBERS, WHERE THE SET OF LOCATIONS IS OF SIZE K
1208
E
CROSSING OVER THE PAIRS AT A RANDOMLY CHOSEN POINT, WITH CROSSOVER PROBABILITY P_c BETWEEN ABOUT 0.6 AND 0.9, TO FORM OFFSPRING TO GENERATE THE NEW POPULATION
1304
WHEREIN CROSSING OVER THE PAIRS AT THE RANDOMLY CHOSEN POINT IS CARRIED OUT BY IMPLEMENTING A GREEDY CROSSOVER OPERATION
OR
D
1306
WHEREIN THE GREEDY CROSSOVER OPERATION COMPRISES GENERATING OFFSPRING IN THE NEW POPULATION BY:
1308
PLACING ALL ADJACENCIES SHARED BY A FIRST AND A SECOND PARENT OFFSPRING
1310
ALTERNATING OTHER ADJACENCIES TO BE PLACED IN OFFSPRING BETWEEN THE FIRST AND SECOND PARENTS
1312
WHEN AN ADJACENCIES PRODUCES A CONFLICT, PLACING A RANDOM LOCATION IN THE OFFSPRING INSTEAD SO THAT A LEGAL TOUR IS MAINTAINED

FIG. 13A

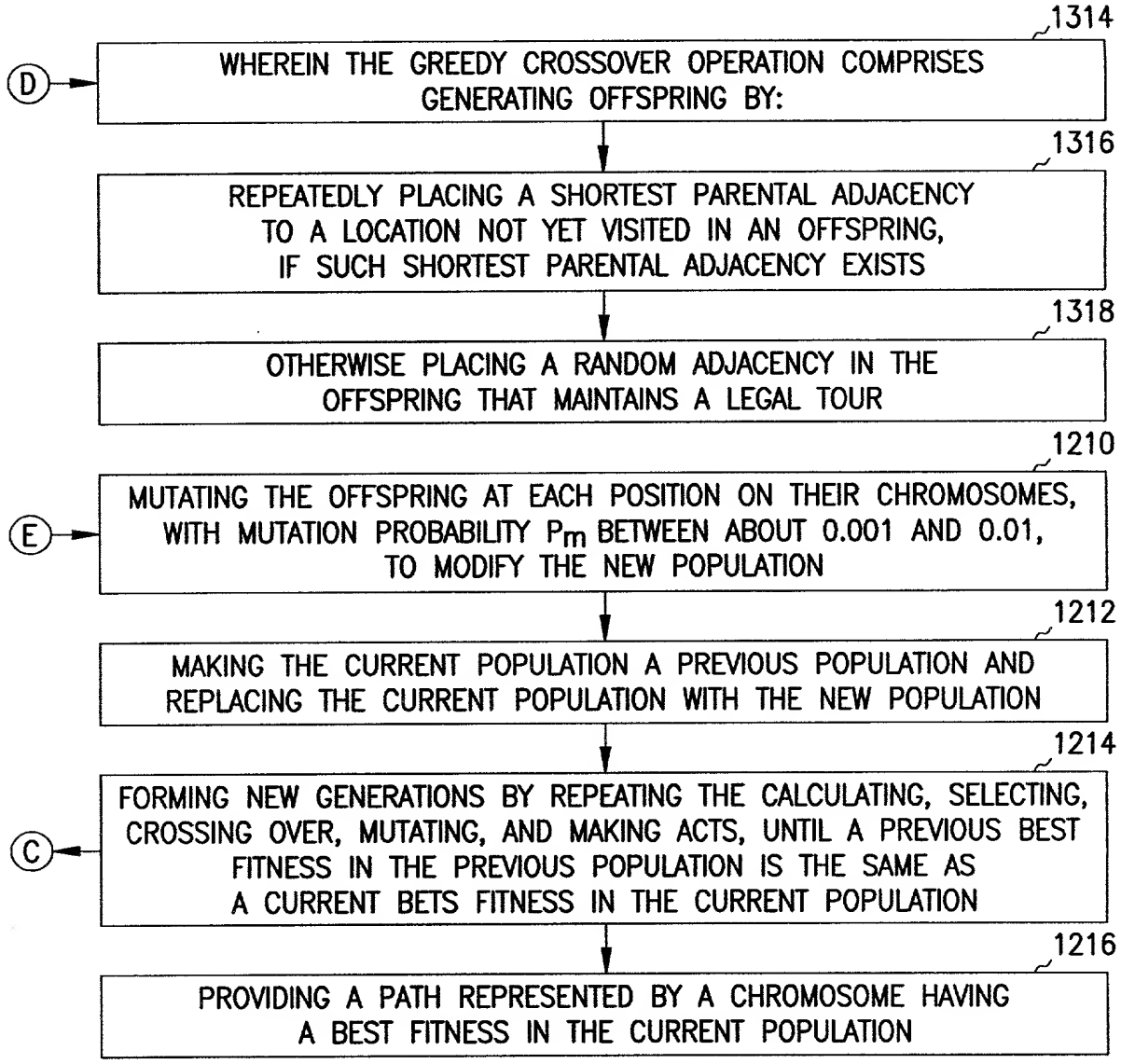
1314
D
WHEREIN THE GREEDY CROSSOVER OPERATION COMPRISES GENERATING OFFSPRING BY:
1316
REPEATEDLY PLACING A SHORTEST PARENTAL ADJACENCY TO A LOCATION NOT YET VISITED IN AN OFFSPRING, IF SUCH SHORTEST PARENTAL ADJACENCY EXISTS
1318
OTHERWISE PLACING A RANDOM ADJACENCY IN THE OFFSPRING THAT MAINTAINS A LEGAL TOUR
1210
E
MUTATING THE OFFSPRING AT EACH POSITION ON THEIR CHROMOSOMES, WITH MUTATION PROBABILITY Pm BETWEEN ABOUT 0.001 AND 0.01, TO MODIFY THE NEW POPULATION
1212
MAKING THE CURRENT POPULATION A PREVIOUS POPULATION AND REPLACING THE CURRENT POPULATION WITH THE NEW POPULATION
1214
C
FORMING NEW GENERATIONS BY REPEATING THE CALCULATING, SELECTING, CROSSING OVER, MUTATING, AND MAKING ACTS, UNTIL A PREVIOUS BEST FITNESS IN THE PREVIOUS POPULATION IS THE SAME AS A CURRENT BETS FITNESS IN THE CURRENT POPULATION
1216
PROVIDING A PATH REPRESENTED BY A CHROMOSOME HAVING A BEST FITNESS IN THE CURRENT POPULATION

FIG. 13B

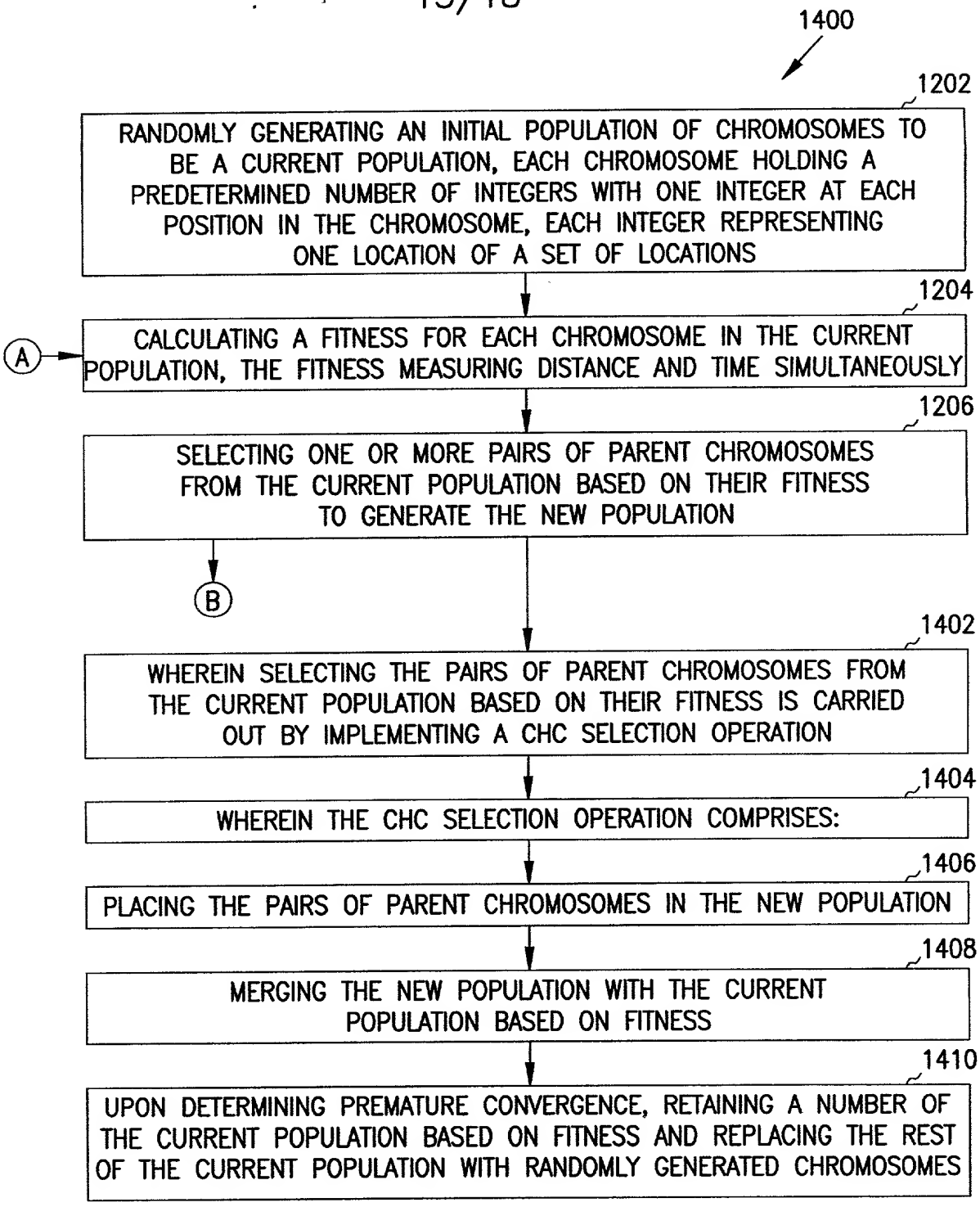
1400
1202
RANDOMLY GENERATING AN INITIAL POPULATION OF CHROMOSOMES TO BE A CURRENT POPULATION, EACH CHROMOSOME HOLDING A PREDETERMINED NUMBER OF INTEGERS WITH ONE INTEGER AT EACH POSITION IN THE CHROMOSOME, EACH INTEGER REPRESENTING ONE LOCATION OF A SET OF LOCATIONS
1204
A
CALCULATING A FITNESS FOR EACH CHROMOSOME IN THE CURRENT POPULATION, THE FITNESS MEASURING DISTANCE AND TIME SIMULTANEOUSLY
1206
SELECTING ONE OR MORE PAIRS OF PARENT CHROMOSOMES FROM THE CURRENT POPULATION BASED ON THEIR FITNESS TO GENERATE THE NEW POPULATION
B
1402
WHEREIN SELECTING THE PAIRS OF PARENT CHROMOSOMES FROM THE CURRENT POPULATION BASED ON THEIR FITNESS IS CARRIED OUT BY IMPLEMENTING A CHC SELECTION OPERATION
1404
WHEREIN THE CHC SELECTION OPERATION COMPRISES:
1406
PLACING THE PAIRS OF PARENT CHROMOSOMES IN THE NEW POPULATION
1408
MERGING THE NEW POPULATION WITH THE CURRENT POPULATION BASED ON FITNESS
1410
UPON DETERMINING PREMATURE CONVERGENCE, RETAINING A NUMBER OF THE CURRENT POPULATION BASED ON FITNESS AND REPLACING THE REST OF THE CURRENT POPULATION WITH RANDOMLY GENERATED CHROMOSOMES

FIG. 14A

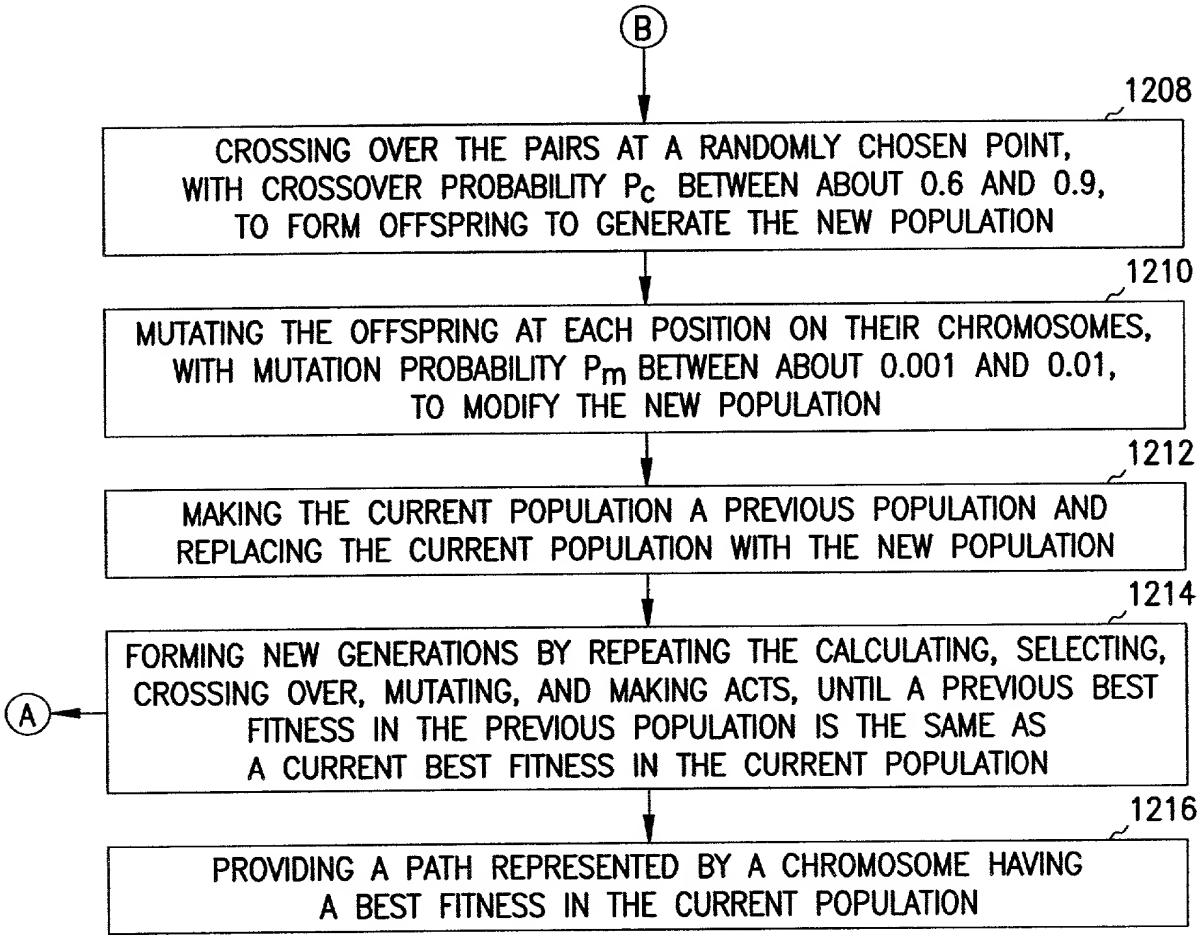
B
1208
CROSSING OVER THE PAIRS AT A RANDOMLY CHOSEN POINT, WITH CROSSOVER PROBABILITY P_c BETWEEN ABOUT 0.6 AND 0.9, TO FORM OFFSPRING TO GENERATE THE NEW POPULATION
1210
MUTATING THE OFFSPRING AT EACH POSITION ON THEIR CHROMOSOMES, WITH MUTATION PROBABILITY P_m BETWEEN ABOUT 0.001 AND 0.01, TO MODIFY THE NEW POPULATION
1212
MAKING THE CURRENT POPULATION A PREVIOUS POPULATION AND REPLACING THE CURRENT POPULATION WITH THE NEW POPULATION
1214
FORMING NEW GENERATIONS BY REPEATING THE CALCULATING, SELECTING, CROSSING OVER, MUTATING, AND MAKING ACTS, UNTIL A PREVIOUS BEST FITNESS IN THE PREVIOUS POPULATION IS THE SAME AS A CURRENT BEST FITNESS IN THE CURRENT POPULATION
A
1216
PROVIDING A PATH REPRESENTED BY A CHROMOSOME HAVING A BEST FITNESS IN THE CURRENT POPULATION

FIG. 14B

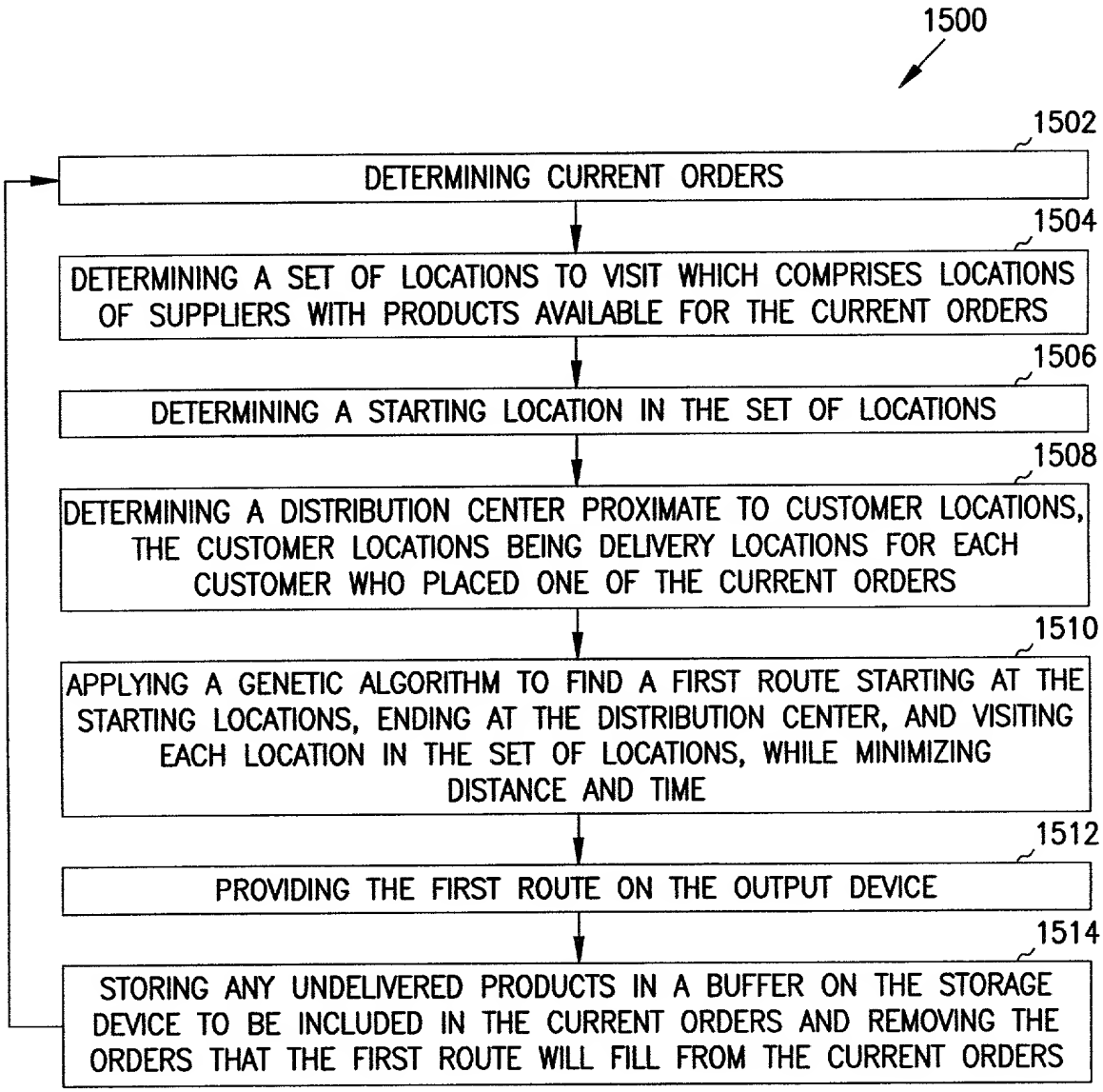
1500
1502
DETERMINING CURRENT ORDERS
1504
DETERMINING A SET OF LOCATIONS TO VISIT WHICH COMPRISES LOCATIONS OF SUPPLIERS WITH PRODUCTS AVAILABLE FOR THE CURRENT ORDERS
1506
DETERMINING A STARTING LOCATION IN THE SET OF LOCATIONS
1508
DETERMINING A DISTRIBUTION CENTER PROXIMATE TO CUSTOMER LOCATIONS, THE CUSTOMER LOCATIONS BEING DELIVERY LOCATIONS FOR EACH CUSTOMER WHO PLACED ONE OF THE CURRENT ORDERS
1510
APPLYING A GENETIC ALGORITHM TO FIND A FIRST ROUTE STARTING AT THE STARTING LOCATIONS, ENDING AT THE DISTRIBUTION CENTER, AND VISITING EACH LOCATION IN THE SET OF LOCATIONS, WHILE MINIMIZING DISTANCE AND TIME
1512
PROVIDING THE FIRST ROUTE ON THE OUTPUT DEVICE
1514
STORING ANY UNDELIVERED PRODUCTS IN A BUFFER ON THE STORAGE DEVICE TO BE INCLUDED IN THE CURRENT ORDERS AND REMOVING THE ORDERS THAT THE FIRST ROUTE WILL FILL FROM THE CURRENT ORDERS

FIG. 15

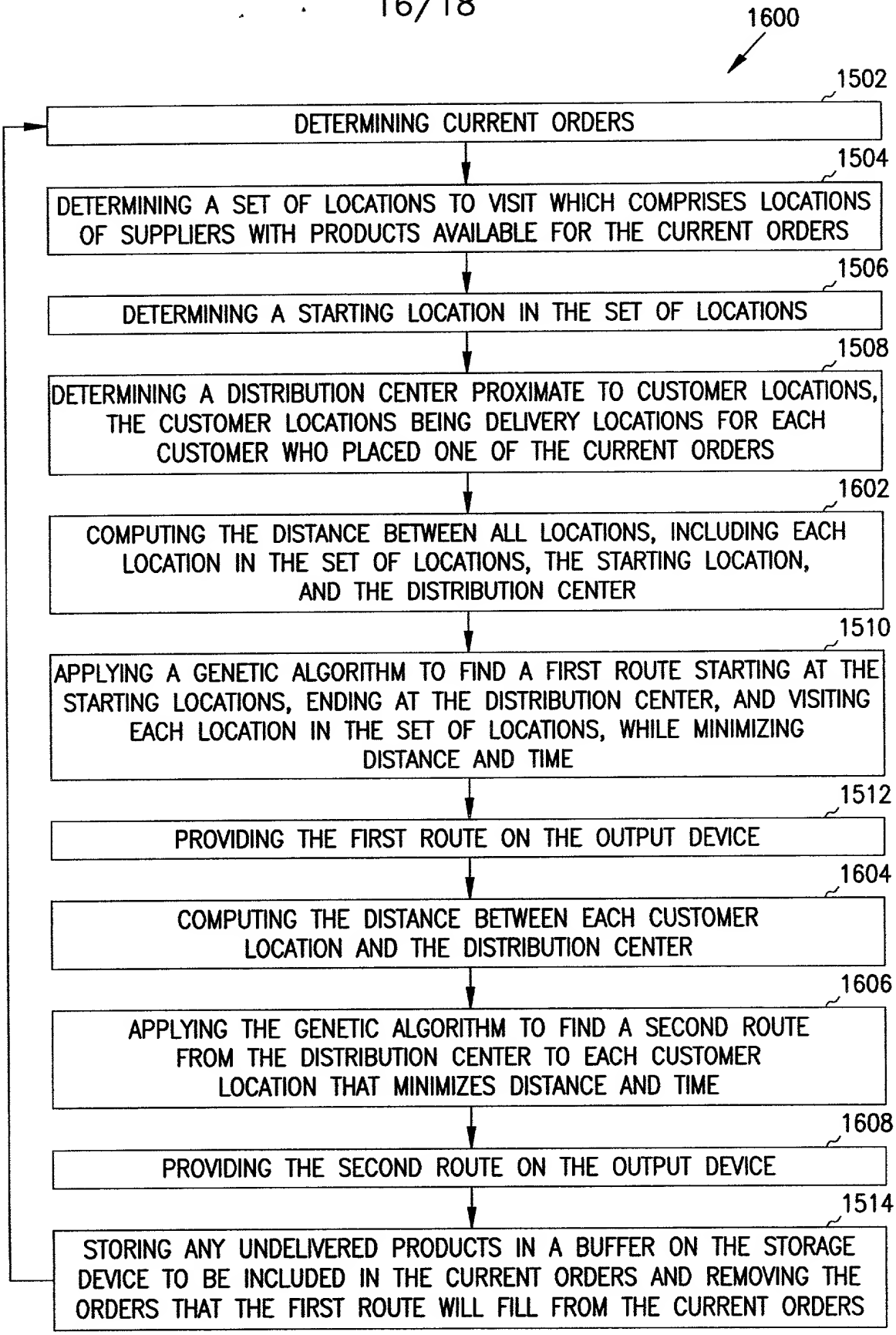
1600
1502
DETERMINING CURRENT ORDERS
1504
DETERMINING A SET OF LOCATIONS TO VISIT WHICH COMPRISES LOCATIONS OF SUPPLIERS WITH PRODUCTS AVAILABLE FOR THE CURRENT ORDERS
1506
DETERMINING A STARTING LOCATION IN THE SET OF LOCATIONS
1508
DETERMINING A DISTRIBUTION CENTER PROXIMATE TO CUSTOMER LOCATIONS, THE CUSTOMER LOCATIONS BEING DELIVERY LOCATIONS FOR EACH CUSTOMER WHO PLACED ONE OF THE CURRENT ORDERS
1602
COMPUTING THE DISTANCE BETWEEN ALL LOCATIONS, INCLUDING EACH LOCATION IN THE SET OF LOCATIONS, THE STARTING LOCATION, AND THE DISTRIBUTION CENTER
1510
APPLYING A GENETIC ALGORITHM TO FIND A FIRST ROUTE STARTING AT THE STARTING LOCATIONS, ENDING AT THE DISTRIBUTION CENTER, AND VISITING EACH LOCATION IN THE SET OF LOCATIONS, WHILE MINIMIZING DISTANCE AND TIME
1512
PROVIDING THE FIRST ROUTE ON THE OUTPUT DEVICE
1604
COMPUTING THE DISTANCE BETWEEN EACH CUSTOMER LOCATION AND THE DISTRIBUTION CENTER
1606
APPLYING THE GENETIC ALGORITHM TO FIND A SECOND ROUTE FROM THE DISTRIBUTION CENTER TO EACH CUSTOMER LOCATION THAT MINIMIZES DISTANCE AND TIME
1608
PROVIDING THE SECOND ROUTE ON THE OUTPUT DEVICE
1514
STORING ANY UNDELIVERED PRODUCTS IN A BUFFER ON THE STORAGE DEVICE TO BE INCLUDED IN THE CURRENT ORDERS AND REMOVING THE ORDERS THAT THE FIRST ROUTE WILL FILL FROM THE CURRENT ORDERS

FIG. 16

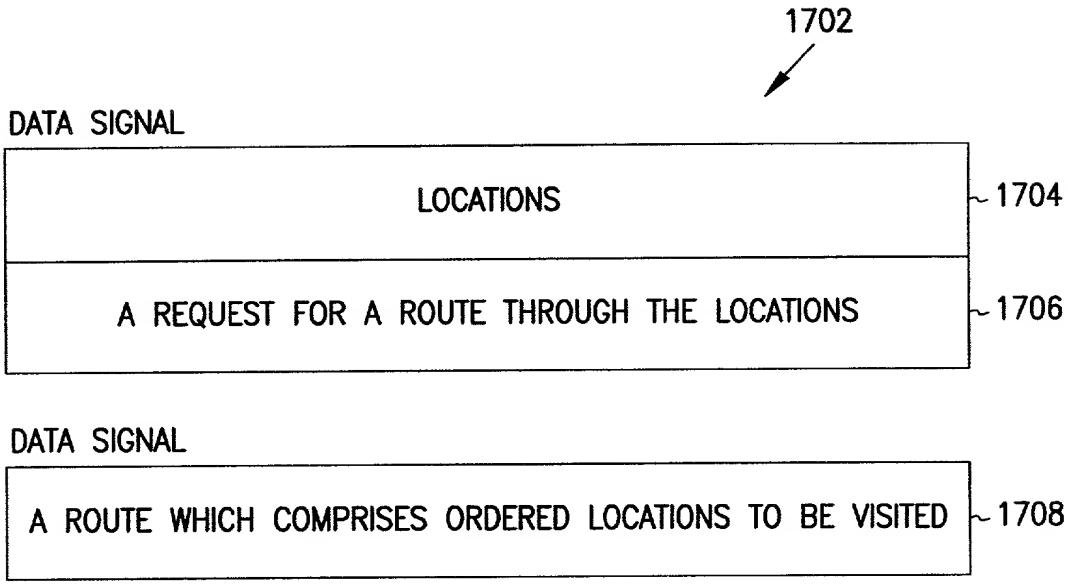
1702
DATA SIGNAL
LOCATIONS
1704
A REQUEST FOR A ROUTE THROUGH THE LOCATIONS
1706
DATA SIGNAL
A ROUTE WHICH COMPRISES ORDERED LOCATIONS TO BE VISITED
1708

FIG. 17

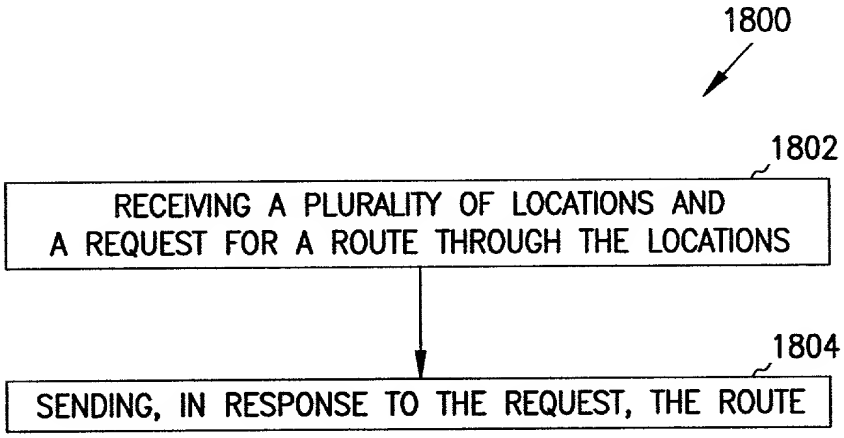
1800
1802
RECEIVING A PLURALITY OF LOCATIONS AND
A REQUEST FOR A ROUTE THROUGH THE LOCATIONS
1804
SENDING, IN RESPONSE TO THE REQUEST, THE ROUTE

FIG. 18

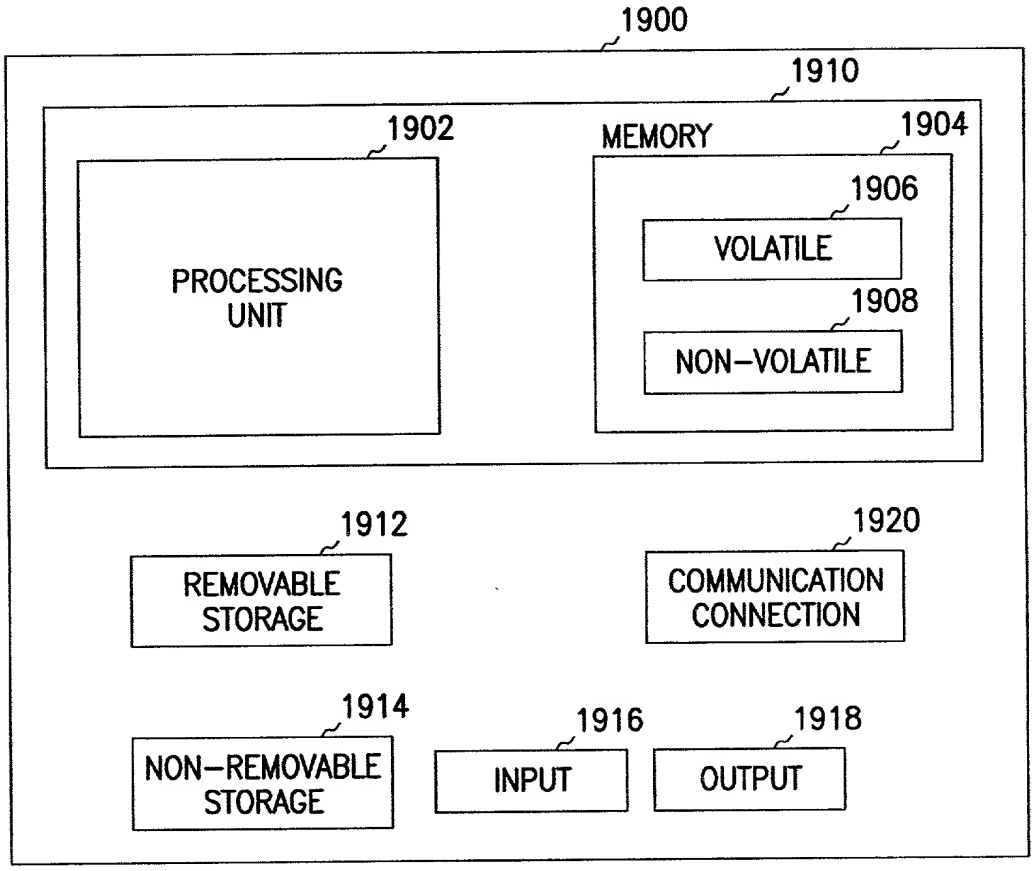
1900
1910
1902
PROCESSING UNIT
MEMORY
1904
1906
VOLATILE
1908
NON-VOLATILE
1912
REMOVABLE STORAGE
1920
COMMUNICATION CONNECTION
1914
NON-REMOVABLE STORAGE
1916
INPUT
1918
OUTPUT

FIG. 19